MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2016/2017

ERT3036 – ADVANCED ROBOTICS

(All sections / groups)
(OPEN BOOK EXAMINATION)

15 OCTOBER 2016
2:30 p.m. – 4:30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of five (5) pages including this cover page with four (4) Questions only.

2. Attempt all **FOUR (4)** questions. The distribution of the marks for each question is given.

3. Please write all your answers clearly in the answer booklet provided.

Question 1

a) For a rigid body on Earth, state all the possible motions. [3 marks]

b) Describe the meaning of the following in terms of dimension and controllable degree of freedom.

i) Non-holonomic [2 marks]
ii) Holonomic [2 marks]
iii) Redundant [2 marks]

c) Professor Stephen Hawking is a famous theoretical physicist from the University of Cambridge. Due to amyotrophic lateral sclerosis (ALS) disease, he can only move around in a differentially driven wheel chair as shown in Figure Q1. The maximum linear speed for each of the motor is 1 m/s. The two encoders are 0.6 m apart.

Figure Q1 Professor Stephen Hawking in his motorized wheel chair
(Picture source: http://time.com/3536998/stephen-hawking-facebook/)

i) If he needs to rotate left (counter clockwise) by 90 degrees on the spot at full speed, find the directions and speed of each motor as well as the duration of this maneuver. [4 marks]

ii) If he needs to reverse in a straight line at full speed, find the directions and speed of each motor. [2 marks]

iii) If he needs to make a left turn with an instantaneous centre of curvature (ICC) of 10m at the fastest speed, find the direction and speed of each of the motor. [4 marks]

iv) Describe how artificial potential field (APF) technique can be used to autonomously send Professor Hawking to his desired destination while avoiding static obstacles along the way. [6 marks]

Continued ...

Question 2

Figure Q2 shows an exoskeleton that can help paralysed patient to walk again. The exoskeleton can be model as 4-link serial system as shown on the right.

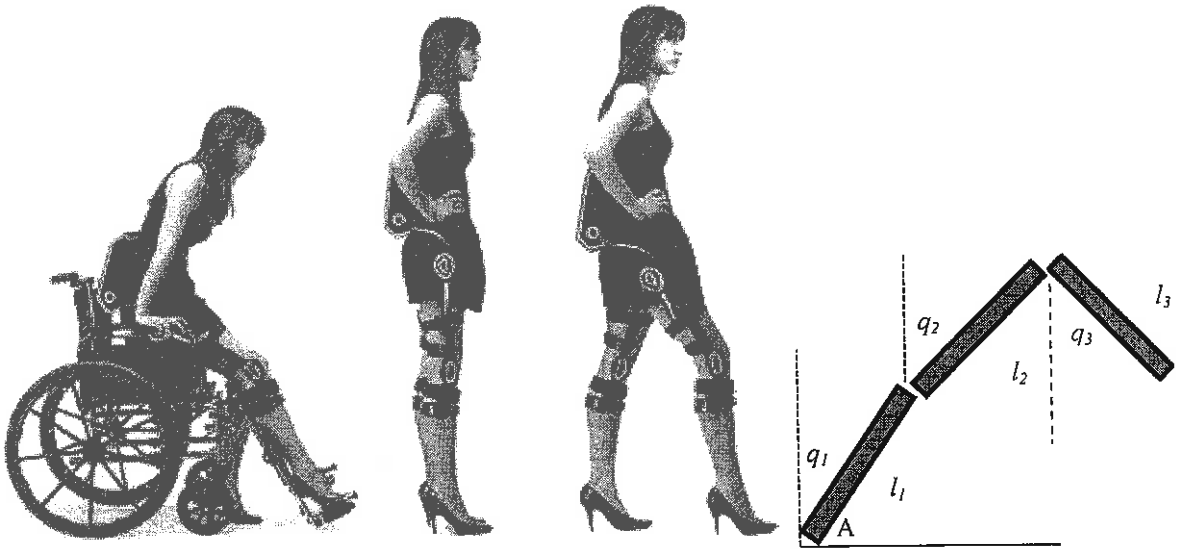

Figure Q2 A sequence of pictures showing exoskeleton at work and its model

(Picture source: http://www.iwebstreet.com/rewalk-is-a-new-exoskeleton-that-lets-paralysed-people-walk-again/)

Let point A be located at (0,0) at the x-z plane (sagittal plane). Link 1 has a length of l_1 and mass of m_1 , link 2 has a length of l_2 and a mass of m_2 and link 3 has a length of l_3 and a mass of m_3. Link 4 is not shown on the model for simplicity.

The angles of link 1, link 2 and link 3 with respect to the vertical z-axis are q_1 , q_2 and q_3 respectively as shown in the model.

i) Locate the coordinates for the centre of mass for link 3 (x_{c3} , z_{c3}). [6 marks]

ii) For link 3, gives all possible sources of kinetic energy. [2 marks]

iii) What is K_3 when the moment of inertial for link 3 is I_3? [9 marks]

iv) Find $\frac{\partial K_3}{\partial \dot{q}}$. [8 marks]

Continued ...

Question 3

Figure Q3 shows a character known as 'Probe' from the Boboiboy animation. It is a character that can fly. As an assistant to an engineer, you are asked to create a flying Probe prototype using quadrotor technology. The prototype weights 2kg eventually. The motor and propeller combination gives $k = 6x10^{-6}$ N/(rpm)^2 and $g = 9.81$ m/s^2.

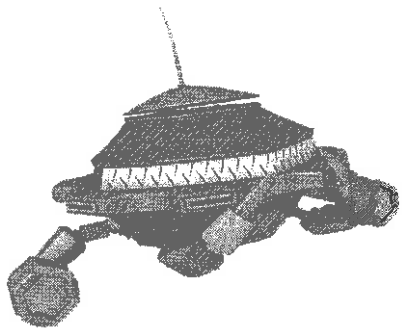

Figure Q3 Character 'Probe' from the Boboiboy animation series
(Picture source: http://terbaruuxz.blogspot.my/2015/03/cara-membuat-id-card-otaku-member.html)

a) What is jerk and how to achieve minimum jerk while taking off? [5 marks]

b). Find the rotating speed, ω_h in rpm when Probe is hovering at 5m above the ground. [4 marks]

c) Probe will be descending from 5m height to the ground without crashing it in 2s.

i) Design the landing procedure. Please provide the rotating speed at each stage of your landing procedure. [10 marks]

ii) What is the maximum vertical drop speed of Probe during this period? [3 marks]

iii) Sketch a speed profile against time for the landing procedure if minimum jerk is desirable. [3 marks]

Continued ...

Question 4

a) Three advances in robotic technology during 2015 and 2016 are featured in Figure Q4. Give a brief description for each of the robotic system.

i) iCub [5 marks]
ii) Cheetah 2 [5 marks]
iii) Cozmo [5 marks]

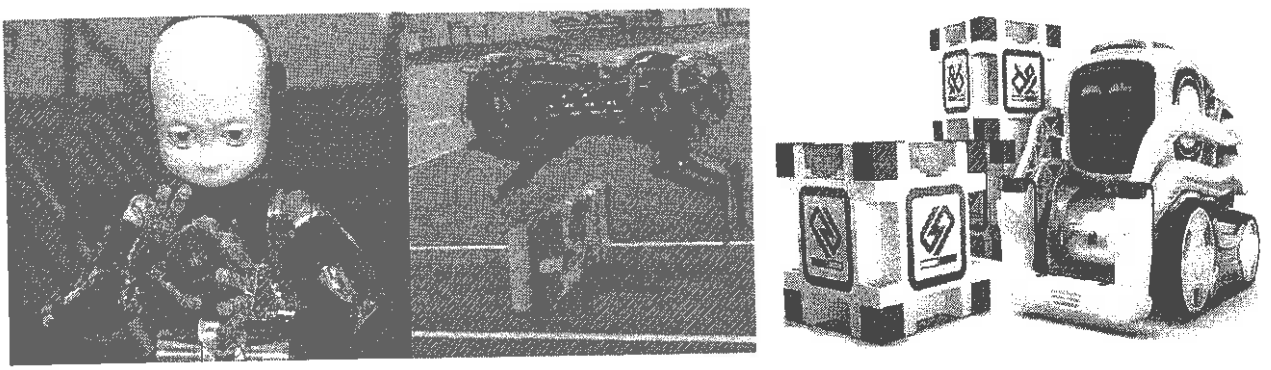

Figure Q4(a) Three advanced robots in 2015/2016

(Picture sources:
http://phys.org/news/2009-09-icub-toddler-robot-videos-pictures.html
https://saboteur365.wordpress.com/2015/06/04/mit-cheetah-robot-lands-the-running-jump-video/
http://theawesomer.com/anki-cozmo-robot/373319/)

b) The Q table for a Q-learning robotic system is shown in Table Q4. At this point of time, the learning rate, $\alpha = 0.3$, and the discount rate, $\gamma = 0.2$. All transitions have reward R = 0 except transition from B to D with a reward, R = 20 and transition from D to D with a reward of R = 30. Transition from A to B, Q(A,B) = 10 at the moment.

Source \ Final	A	B	C	D
A	0	10	4	2
B	5	2	0	7
C	2	2	1	3
D	1	3	0	2

Find the final Q values for the following transitions in sequence:

i) From A to B, Q(A,B). [2 marks]
ii) From B to D, Q(B,D). [2 marks]
iii) From D to D, Q(D,D). [2 marks]

c) Compare the rigid arm and the compliant arm of a robotic system. [4 marks]

End of Paper